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# Computerized ICU data management: pitfalls and promises

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## Introduction

Implementation of a comprehensive patient data management system (PDMS) is increasingly attractive in this era of advanced technology, prospective payment and cost containment. Today's successful hospital must offer care that is both medically effective and cost effective. Although intensive care units (ICUs) represent the utmost in care for critically ill patients, they account for approximately 20% of expenditures in United States hospitals [1]. ICU care requires both minute-to-minute monitoring and integration of data from a wide variety of sources to permit prompt, appropriate diagnostic and therapy decisions. Although vendors have marketed ICU data management systems for nearly 15 years, such systems have not yet gained wide acceptance [2]. Many installed systems were never successfully implemented and are now turned 'off'.

At the 1989 Symposium on Computer Applications in Medical Care (SCAMC) Reed Gardner and Mike Shabot presented a tutorial on computerized ICU data management. The two systems developed by the authors, the HELP at LDS Hospital, and the PDMS at Cedars-Sinai Medical Center are clinically valuable and highly used. They outlined why it is important to address critical design and functionality issues before ICU systems are installed. They focused on key elements of the implementation process including the conversion from manual to electronic flowcharts and training of nursing and medical staff. They also discussed: interfacing with laboratory systems, integrating the new Medical Information Bus (MIB), assimilating computers into the bedside care process, computerized alerting schemes, decision support tools, automated acuity measurements, use of bedside terminals, integration of all hospital systems for patient care, implementation of protocols and projections for future computer applications.

## Overview

### *Medical informatics*

Medical Informatics is a field of study concerned with the broad range of issues in the management and use of biomedical information, including medical computing and the study of the nature of medical information itself [3]. This new discipline combines the skills of computer scientists, medical practitioners, nursing expertise, and a sense for the clinical application of computers [4, 5]. There are now several Medical Informatics Departments in universities in the USA and abroad.

It is recognized that traditional handwritten paper records have several significant limitations:

1. It might be physically unavailable.
2. It is often poorly organized, available only in the order it was recorded and many times is illegible.
3. ICU instruments, which are now entirely electronic and digital, require that their data be taken by a human and handwritten into the chart.
4. Retrieval of data for research is time consuming and cumbersome.

Several investigators have shown that structured flowcharts are more effective in caring for a patient

[6]. As a result, the application of computers and medical informatics offers a unique opportunity to help in the care of the critically ill.

*Clinical and administrative*

The acquisition of nursing, medication, respiratory care, laboratory, and real time physiological data by a computer allows the prompt and efficient integration of data for medical decision-making. Computerized ICU decision support can be as simple as well organized screens and reports for review by clinicians or as complex as automated assessments, diagnoses and treatments ordered by the computer. In either case and for many tasks in between, a PDMS computer can be of great benefit. Data collected for clinical purposes can be secondarily analyzed for administrative advantages. Careful documentation of patient care activity, severity of illness, medical procedures performed, medications given, etc. can provide productivity and staffing benefits [7, 8].

Medical data, whether stored in the conventional paper record format or in a computer, must be kept confidential ]9, 10]. One of the concerns of administrators is that computers will allow easy breach of the patient's confidentiality. However, most ICU computer workstations are 'secure by location,' that is, they are in the ICU and under the watchful eye of the staff. It seems inappropriate to lock up ICU terminals more securely than patient's bedside charts. Remote access poses different problems. Security login capabilities on computer systems seem adequate to prevent breaches of confidentiality, and to date no legal action has been taken from such a breach.

**Data sources and use**

*Required clinical data*

One of the most important features of a computerized ICU is its ability to integrate data from multiple sources [3, 6, 11, 12, 13, 14, 15]. A recent review of data sources from a cardiac surgical ICU showed that data from 18 different sources were required to make the computerized charting system effective [12]. Laboratory data is by far the most important data acquired from outside the ICU [11, 12].

Computer charting in the ICU must support multiple types of data collection to be effective, because a large portion of the data needed for medical decision-making comes from manual tasks such as bedside observations and administration of medications.

*Networks and standards*

The absence of standards for communications with bedside medical devices has showed the acceptance and success of automated ICU systems. The Medical Information Bus (MIB) promises to correct this condition with a powerful bedside communications interfacing method. The Institute of Electrical and Electronic Engineers (IEEE) is now actively involved in establishing standards for the MIB under its P1073 MIB committee. With this standard in place, it will be possible to communicate with any device at the bedside and bring the data into a computerized database. Until such a standard is available, it is impractical for most hospitals to build all the special interfaces required [16, 17, 18, 19, 20].

Once the standard MIB interface is available, there will still be important problems to work out such as:

1. What data do you collect?
2. How much data do you collect?
3. How often do you collect data?
4. How can you assure the quality and validity of the data [18]?

In 1986, a group of interested scientists banded together to help establish a medical data interchange standard now known as MEDIX [21]. The purpose of the standard is to simplify the exchange of data between various hospital systems; for example, when there is need to communicate between a laboratory and an ICU system. The com-

mittee is an active IEEE committee, P1157. The scope of the committee is broad and the forthcoming standard will have a dramatic salutary effect on our ability to integrate data from multiple locations within and outside the hospital.

*Medical use of data*

Medical data are used by physicians and nurses to monitor and treat patients. The time critical nature of ICU patient care amplifies the necessity for prompt, accurate, and thorough analysis of the data. Computerization assists physicians and nurses by presenting data integrated from multiple sources (laboratory, pharmacy, bedside monitors, nurses, respiratory therapists) to generate specialized reports, provide clinical alerts and efficient data communications among the health care team.

Recently, computerized patient care treatment protocols have been developed that prompt the treatment of a critically ill patient [22, 23, 24, 25]. These protocols have had a salutary effect on patient outcome.

**ICU data management**

There are many advantages to computerized charting. Some that have been observed are:

1. Data is available for review promptly
2. Documentation is more legible
3. There is a minimum of duplicate charting
4. The computer can remind nurses to chart important or missing data items
5. Time spent making calculations is eliminated, and the results are more accurate
6. Recognition of important patient trends is enhanced
7. Multiple patient problems are followed more easily
8. There is better shift-to-shift nursing care continuity
9. The quality assurance process becomes more automated
10. Effective alerts for life threatening laboratory abnormalities or other adverse events is possible
11. Patient acuity scoring can be automated.

There have been very few controlled studies on the efficiency of nurses using computers to chart. In a recent study it was found that nurses spent a smaller portion of their time in direct patient care after computerization [7]. However, these changes were attributed to a decrease in the severity of patient's illness, rather than the availability of the computer. In 1989, Leyerle reported on an evaluation of Cedars-Sinai's PDMS performed by an independent, national consulting firm. Compared to similar non-computerized ICU's, the PDMS was estimated to save 50% of flowsheet charting time, or 7.5 minutes per nursing hour [26].

In a recent interview study conducted in the post open heart ICU at LDS Hospital, nurses were asked what they liked about their computerized ICU. Twenty-one nurses made the following observations:

1. 100% said that prompt laboratory data review was helpful
2. 95% said that having more and better organized reports was a benefit
3. 95% said that the change of shift nursing report time was more accurate and effective with computer charting
4. 76% said they found that the ability to follow the progress of their patient in the operating room was helpful
5. 43% said that having the MIB collect data for them was a benefit
6. 43% said that the computerized acquisition of vital signs (heart rate and blood pressure data) was of value
7. 33% felt computerized records were more accurate
8. 33% felt the integrated computer record was an advantage
9. 29% felt the more legible record provided by the computer was an advantage
10. 29% said that the automated acuity calculated from their charting was an advantage
11. 29% said they could chart faster with the computer than by hand

12. 24% said they did less writing with computer charting.

The same interview process asked nurses what they did not like about the computerized charting. The same nurses responded as follows:

1. 71% did not like the downtime associated with computer based charting (for the HELP system the up-time is now at 99.3%!! – still not good enough)
2. 48% felt that the system was too slow at times
3. 43% said that editing data was too difficult
4. 24% complained about the complexity of scheduling medications
5. 19% said that the time to become proficient was too long
6. 14% complained that there was still need to do some duplicate handwritten charting.

These findings from a mature computerized system should be a signal to those planning and developing computer systems about the sensitivities of nurses. Similar findings were made by Avila and associates [14].

Evaluation of the need for bedside versus centrally located terminals showed an overwhelming sentiment by nurses for bedside terminals. Data were entered in a more timely fashion with less waiting when bedside terminals were available. Physician response to computerized nurse charting was found to be favorable [8].

*Administrative/quality assurance/utilization review issues*

Indicators of severity of illness are required to normalize objective studies of ICU morbidity, mortality and appropriateness of ICU utilization. The APACHE and other scoring systems have been designed to do such normalization [27, 28, 29, 30]. Unfortunately, nearly all the scoring systems require manual chart review and hand tabulation of results, and are not available for use in real time. Computerized ICU systems can integrate all the required data and makes possible the real time assessments of appropriateness of utilization. Computer systems have proven that they can be used for analysis of ICU management practices, quality assurance, prospective staff planning and normalization of prospective critical care research studies [8, 27].

In 1976 McDonald showed the benefits of a computerized physician reminder system in the care of outpatients [31]. Others have shown the benefit of such systems on inpatients [32, 33, 34, 35]. Recently the advantages of such a system have been shown in the ICU. Use of laboratory alerts in the ICU is possible and desirable. Detection of life threatening events may allow for earlier and more appropriate treatment of patients [32, 33, 34, 35, 36].

**How to do it – build vs buy**

*Build*

Nearly all successful ICU information systems in operation today, with more than a year of experience, have in major part been built by the staffs at the hospitals where they are located. For the LDS Hospital this was done by using the features of the HELP system. Cedars-Sinai Medical Center started with a Hewlett-Packard PDMS and then enhanced it significantly. They interfaced a clinical laboratory computer, blood gas computer, electronic urimeters and pulse oximeters to the PDMS. Each of these tasks requires hardware and software knowledge and expertise. Both of these systems have required the development of special hardware, electrical power, and air conditioning adaptations. The HELP system is built around a TANDEM computer system that has built in back-up capability for computer processor or disk failure. The PDMS system has a backup processor and disk drive available to switch to if there is a primary hardware failure. Both systems have uninterruptable power supplies provided by a motor generator with a large flywheel or battery back-up. Both systems have redundant air conditioning systems. Despite the advancements made with the most recent vendors in the ICU computerization marketplace, it likely for the next 5 to 10 years that users will have to build some of their own system interfaces. A word to the wise: buy everything you can!!. Be certain the system you buy will interface

the existing systems already in your hospital. Make such a guarantee part of the contract!

*Buy*

Today any potential purchaser of a computerized ICU system should carefully review systems in the marketplace. Be wary of 'vaporware' or flashy displays of 'demo' software. Ask for a list of hospitals with operational systems, and then visit them. Beware of vendors who claim they can do more for you than you believe can be done after reviewing real, operational systems. A list of some vendors offering ICU computer systems is provided in Table 1.

## System tours

Much has been written about the two systems developed and used by the authors. The HELP system application at LDS Hospital was started as a pilot project in 1967 [3, 6, 7, 8, 11, 12, 16, 17, 18, 22, 23, 24, 25, 32, 33, 36]. The PDMS system at Cedars-Sinai Hospital was built on the experience of Hewlett-Packard and work done at Harbor-UCLA Medical Center by Dr. Shabot [13, 14, 19, 26, 27, 28, 34, 35].

## Conclusion

There was not complete consensus of the presenters at the tutorial. The two presenters had different opinions and experiences. At times the differences were dramatic and showed that there were important and honest differences in opinion. However, the areas of consensus and agreement far outnumbered the disagreements. As the title of the tutorial suggests, there are both promises and pitfalls to be anticipated when implementing computer technology in the ICU.

The expectations of society for medical progress and increased use of computers for diagnosis and treatment are fueled by the increased use of computers in every day life, in science fiction movies, and by the eternal optimism that drives the curiosity about the future. Great strides have been made in the understanding of how to harness computer technology to help the health care professional in the care of the critically ill patient.

It seems clear that advances in the use of computers in the ICU will be evolutionary rather than revolutionary. Part of the health care system will require change to optimally integrate computer technology into the care process. The way health care professionals work and interact with their colleagues will change. Intensive care medicine is ready for the new opportunities offered by computers.

*Table 1.* ICU Computer system vendor list.

| Vendor/'Product Model' | Representative | Phone |
|---|---|---|
| ACT/PC 'ARGUS 2000' | Joel Gochburg | (608) 273–8860 |
| CliniComp | Chris Haudenchild | (619) 456–0361 |
| EMTEK 'System 2000' | Harry Comanchero | (800) 633–6835 |
| Hewlett-Packard 'Careview 9000' | John Mitchell | (617) 890–6300 |
| Marquette Electronics 'EPIC' | John Stein | (800) 658–5120 |
| Mennen Medical 'Patient Data Network' | Michael Guzzetta | (800) 223–2201 |
| QMI | Mark Stega | (202) 537–0643 |
| SpaceLabs 'Chartmaster' | Dan Soule | (800) 882–3700 |
| Trinity Computing 'ICU-Link' | Dan Oberle | (800) 231–2445 |

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